FINAL REPORT

THE DEVELOPMENT OF AN AAIT MODEL OF
THE SAAB 340

Requesting Authority:	FAA Technical Center
Project Co-ordinator:	A. Walton
Project Engineer:	R. Hashemi
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(1) OBJECTIVE

The objective of this study was to develop an AAIT model of the SAAB340 aircraft for inclusion in the AAIT aircraft library. This aircraft had not previously been drop-tested by the FAA.

The model basically consisted of the crew cabin, fuselage section and the wings, including contributions of the landing gears and the fuel tanks. The model construction was based on the geometrical and physical data available to CIC.

(2) MODEL CONSTRUCTION

A 3-D model was constructed of the SAAB340 aircraft using the AAIT KRASH program. The model of the aircraft consisted of the main fuselage, wings, landing gear, rudders and rear stabilisers.

The model was constructed in the conventional format and consisted of lumped masses, (with mass-less nodes that modelled rigid connections); beams that represented aircraft structural members and contact springs that defined the crush-characteristics of the aircraft lower-structure in contact with the ground.

Note that the available data on the aircraft was limited to basic weight information along with selected engineering drawings that defined the cross-sectional dimensions of key structural members. This information excluded essential data on the elastic limit-loads and the post-failure characteristics of the primary and secondary structures.

In the absence of the readily available geometrical and technical data, a comparative study, based on a number of aircraft of similar size and capacity for which the data existed, was carried out. They included Beechcroft 1900C, Metro III and Shorts 330. The parameters used for the comparisons were wing and fuselage data, weight and capacity. The latter aircraft, compared with the SAAB 340, appeared to comply closely with the criteria and hence was selected as the base model.

The model geometrical and physical data were based on information obtained from the FAA (Refs. 1, 4), the UK Civil Aviation Authority, Shorts of Belfast (Refs. 2, 3) and the structural repair manual purchased from the aircraft manufacturer (Ref. 5).

(2.1) Mass Properties of Model

Data was extracted from the design information to obtain a distribution of lumped masses that approximated the actual mass distribution of the aircraft. Information on the exact weight and mass moments of inertia of individual components of the structure was not available, with the exception of the aircraft engines and propellers. Consequently, an approximation method had to be used which distributed the known total weight of the aircraft across the lumped mass points iteratively, until a satisfactory balance point was attained on the aircraft model.

The final version of the model consisted of 57 lumped masses. The weight of the model in its empty state, i.e. without fuel, cargo, passengers and crew, was 18168.54 lbs (18 145.00 calculated by KRASH program).

(2.2) Beam Properties of Model

The primary structural members of the aircraft were identified from the supplied data. These were idealised as beam elements for the purpose of the model and the elastic-properties of these beams were derived. The elastic section properties consisted of the cross sectional area (A), the torsion constant (XJ) and the second moments of area (IYY, IZZ). Due to unavailability of data, a limited number of beam properties were based on the estimates of similar sections (Refs 2 and 4). In total, 97 beam elements were used to model the aircraft.

No data was available which defined the location of regions of major failure within the structure. Consequently, the failure characteristics, in terms of failure type (axial, bending, torsional, shear), elastic force limit, post-elastic force/deflection (or moment/rotation) and ultimate yield load were also unknown.

(2.3) Contact Springs

In total there were 39 contact springs in the model. These were positioned to define interaction between the fuselage floor, engines and the wing tips with the ground.

In the absence of appropriate information, data from the vertical drop test of a Beechcraft 1900C (Ref. 4) was used to represent the fuselage floor vertical crush response.

(3) SIMULATION RESULTS

The completed SAAB 340 model was used to simulate the 30 feet per second and hence representing type of drop test conducted by the FAA. Note that the landing gear is usually removed from the aircraft prior to the drop test and this modification was also applied to the model for this simulation run only. The simulation was performed for 200 msec. The deformed structure exhibited collapse in the wing and the fuselage centre section.

Figures 1 to 2 show the model in terms of location of lumped mass points, rigid connections, beams and contact springs. The initial and final states of the simulation and the resulting accelerations at station 321 are shown in Figures 3 to 6.

(4) REFERENCES

(1) Shorts SD3-30 Repair Manual and General Data (1-00 to 1-90) Provided by FAA.

(2) "Report No. 2, SD3-30 Weights", Bombardier Aerospace, Shorts Technical Engineering Department, Belfast, October 1975.

(3) "Report No. 4, Basic Structural Data", Bombardier Aerospace, Shorts Technical Engineering Department, Belfast, September 1975.

(4) McGuire RJ, Vu T; "Vertical Drop Test of a Beechcraft 1900C Airliner", Final Report DOT/FAA/AR-96/119, Federal Aviation Administration, Airworthiness Assistance R&D Branch, William J. Hughes Technical Centre, Atlantic City International Airport, NJ, USA, May 1998.

(5) LFV Approved Structural Repair Manual including SAAB-Fairchild 340A, SAAB SF340 A, SAAB 340B. Doc No. 72LKS 3079, Ref. No. SAAB 340 SRM 000, Revision 36, July 2000. Document is also FAA-Approved for U.S. Registered Airplanes in Accordance with the Provisions of 14 CFR Section 21.29, and is Required by FAA Type Certificate Data Sheet No. A52EU.

(6) Jane's All the World's Aircraft 1990-91, Eighty First Edition, Edited by M Lambert, Jane's Information Group.

APPENDIX A

NOTES ON THE ASSEMBLY OF AN AAIT MODEL FOR A SAAB 340

(A1) Data Sources

Engineering data was extracted from the following sources:

The manufacturer's published Service and Parts manuals for this aircraft obtained from SAAB of Sweden and also information by the UK AAIB in microfiche form.

(A2) Modelling Notes on Structure

A model of the aircraft in KRASH model format was developed. As a vertical impact would involve major crushing of the cabin floor and wings (with the exception of landing gear for a dis-engaged scenario), the primary emphasis in this simulation was placed in modelling the floor and wing structure. The software limitation on the total number of lumped masses, beams and springs meant that apart from fuselage and wings other areas of the structure had to be modelled in less detail.

In order to minimise the number of lumped masses in the model, it was decided to represent the remainder of the fuselage aft of cargo section station ST622, (rear of the seated section), as a single mass point. This included the mass of the vertical and horizontal stabilisers and associated structure.

A review of the components of the underfloor of the aircraft indicated this was composed of longitudinal stringers and lateral crossmembers enclosed by an outer skin on the lower surface and floor panels on the upper tread surface. These were connected by the lateral crossmembers that supported the stringers and outer skin. In addition, the wing spars (front, middle wing box and rear) were major lateral structural members that connected across the longitudinals.

As there was variation in the size and anticipated strength of each of the underfloor crossmembers, it was decided that only those considered, as major members were to be included in the model, due to model size limitations. A list of included and excluded underfloor bulkheads is shown in Table 1.

INCLUDED	EXCLUDED
ST 121.5 Nose	
ST 180.1	
ST 236.5 (ST 231)	
	ST 294
ST 321	
ST 411.9 Wing Box	
ST 439.5 Wing Box	
ST 475.5 Rear Spar	
	ST 487
ST 548	
ST 608 (ST 622)	
ST 686.9	
	ST781.3

Table 1 Included and Excluded Underfloor Crossmembers

The idealisation of the structure was completed into a distributed set of lumped mass points (and rigid nodes), connected together by beam elements. This included the attachment of crush spring elements to selected mass points (and nodes) which were expected to contact the ground surface.

(A3) Weight Distribution

(A3.1) Major Mass Items

An approximate distribution of structural and equipment mass between the mass points of the model was made. This was based on the available data (Refs. 5, 6). It should be noted that detailed mass and inertia data on individual components was not available. Consequently, the mass distribution conducted for the model provided an approximation to the actual mass distribution of the aircraft.

The following mass data was extracted from the available data, see Table 2.

MASS DISTRIBUTION	NO. OF MASSES	TOTAL MASS (lbs)	PROPORTION (%)
Fuselage (crew cabin + front landing gear)	8	1611.95	8.89
Fuselage (passenger cabin)	42 (2 shared with wings)	8766.91	48.27
Fuselage (cargo + stabilisers)	1	1483.86	8.18
Wings + Main landing gears	6 (2 shared with fuselage)	4640.82	25.56
Engines	2	1643.00	9.10
Total	57	18168.54	100.00

Table 2 Major Mass Items

(A3.2) Fuselage Structure Mass Distribution

The weight of individual components of the fuselage structure was not known. As a consequence the distribution of the fuselage weight between mass points was carried out by dividing the fuselage into 10 sections. Each section had a weight of 208.736 lbs at each mass point.

For each section, the distributed weight was divided by a ratio of 2:1 in favour of mass points lying in the lower half of the fuselage. This represented the bias of grater mass in the lower structure of the fuselage.

FUSELAGE LENGTH LOCATIONS (in)	DISTRIBUTED WEIGHT (lbs.)	ACCUMUL ATED WEIGHT (lbs.)
121.50	208.736	208.736
180.10	208.736	1461.152

231.00	208.736	1252.416
321.00	208.736	1252.416
411.90	208.736	1252.416
439.50 (incl. Wing Spars)	460.176	2628.628
475.50	208.736	1252.416
548.00	208.736	1252.416
622.00	208.736	1252.416
790.12 (incl. Stabilisers)	1483.860	1483.860

Table 3 Fuselage Mass Distribution between 10 Sections of Fuselage

(A3.3) Beam Element Cross Section Properties

The generated cross-sectional elastic stiffness properties of selected beam elements are tabulated in Table 4.

Section	Cross Sectional Area (in2)	Second Moment of Area, IY (in4)	Second Moment of Area, IZ (in4)	Torsion Constant, J (in4)
Floor Longitudinal	0.81	7.13	1.00	6.94
Floor Cross Members	0.81	7.13	1.00	6.94
Roof Longitudinal	0.23	24.00	24.00	240.00
Roof Cross Members	0.52	1.96	0.02	1.90
Wings	12.00	165.00	16.50	165.00

Table 4 Section Properties

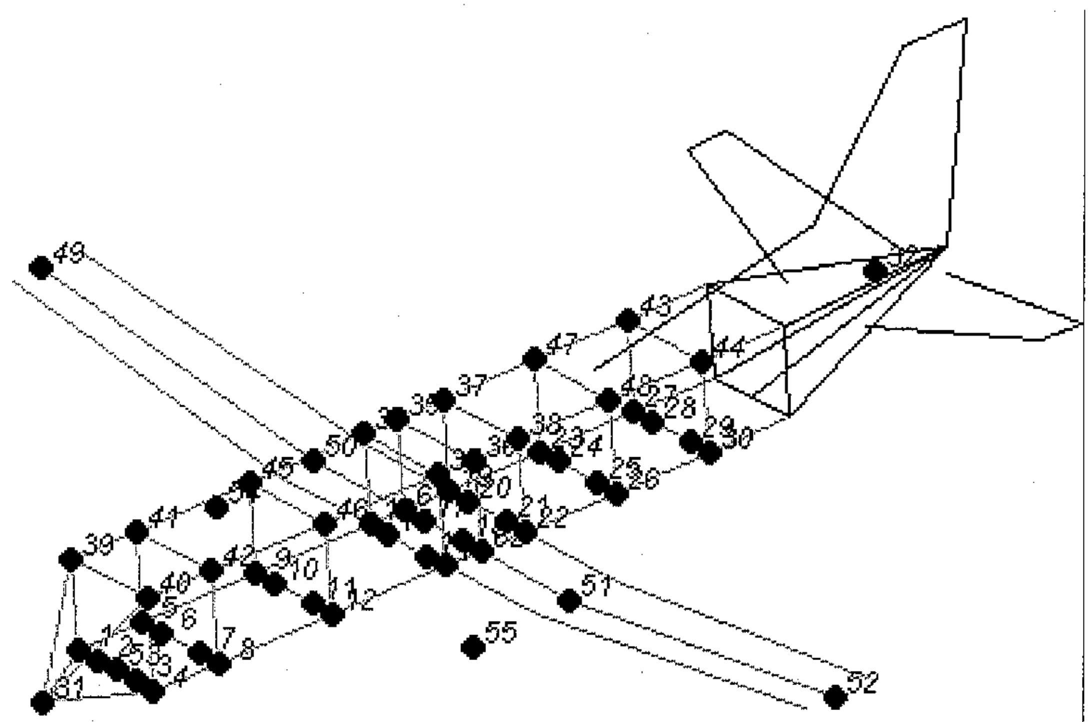

FIG 1 – MODEL LAYOUT SHOWIN GLUMPED MASS POINTS

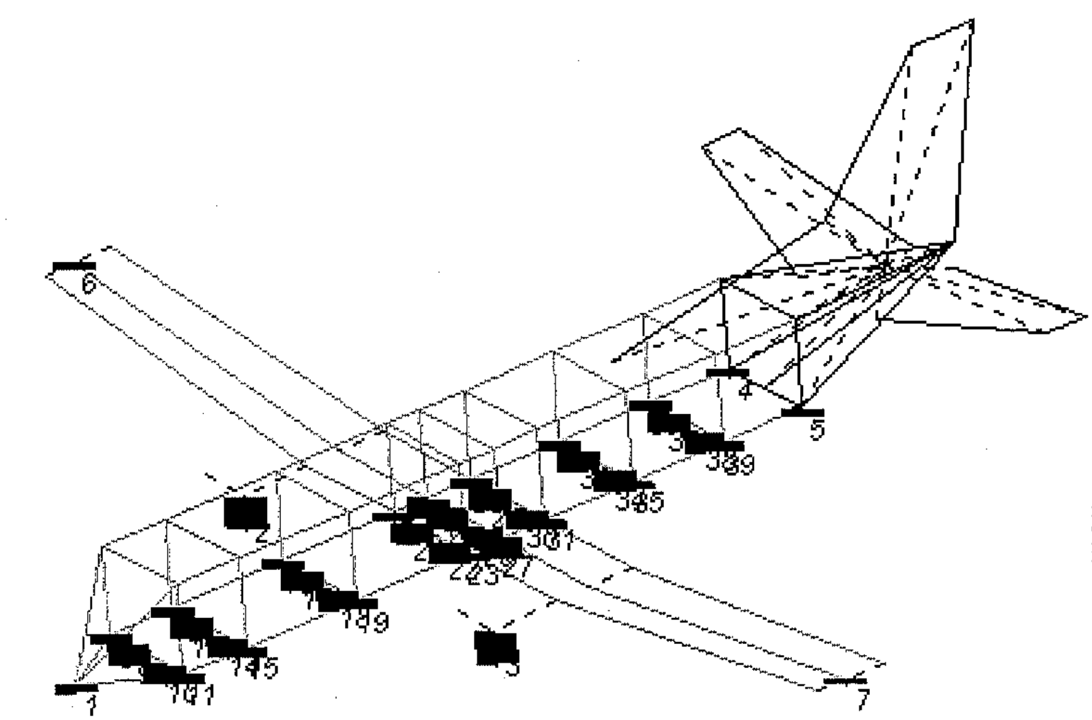

FIG 2 – MODEL LAYOUT SHOWING CRUSH SPRINGS AND RIGID LINKS

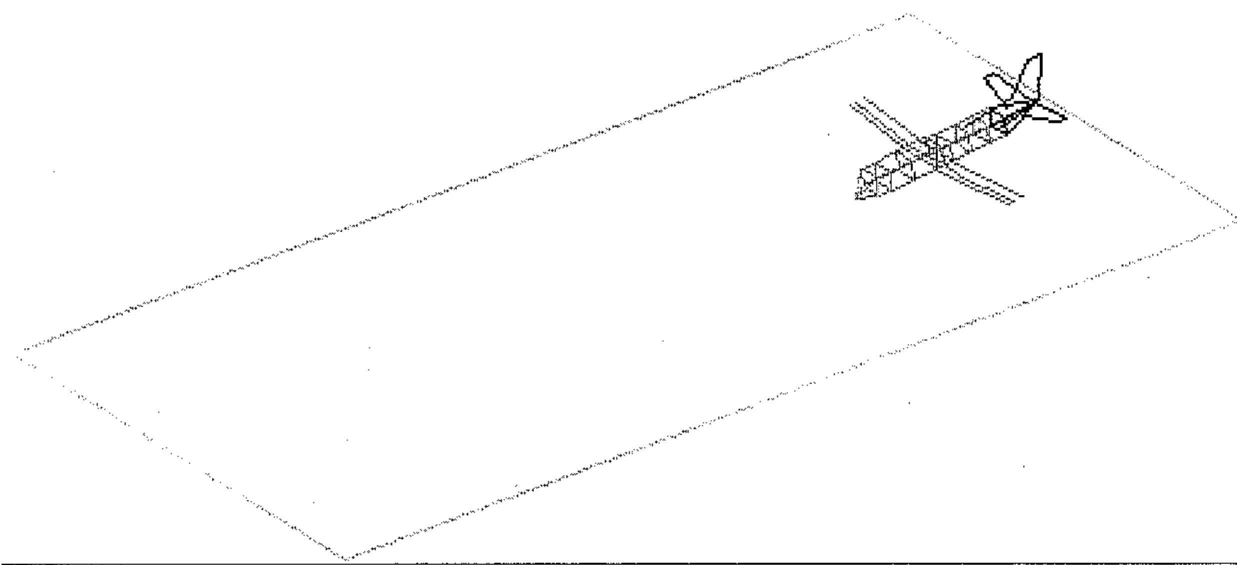

FIG 3 – INITIAL CONTACT POSITION

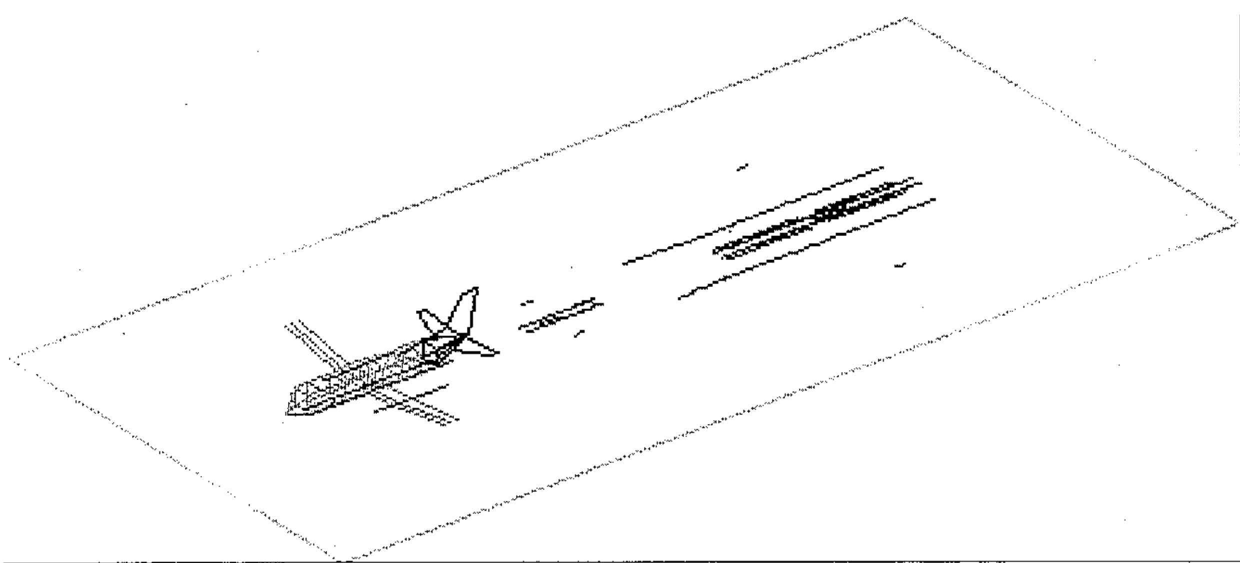

FIG 4 – POSITION AT 1.0 SECONDS WITH CONTACT TRACKS DISPLAYED

FIG 5 – VERTICAL ACCELERATION AT STATION 321

FIG 6 – LONGITUDINAL ACCELERATION AT STATION 321